Evaluation of subcritical water reaction media for an efficient conversion of the polysaccharide fraction to lactic acid by $Ca(OH)_2$ catalysis

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Background

General aim: Transit from a fossil based to a bio-based economy to produce high value chemicals.

Mean: Subcritical water treatment (SWT) of second-generation lignocellulosic biomass, specifically, corn stover.

Specific work: Selective production of production of lactic acid (LA) from corn stover by alkaline catalysis, using $Ca(OH)_2$ as catalyst

Equipment & Methodology

Discontinuous SWT operation: 0,5 L reactor

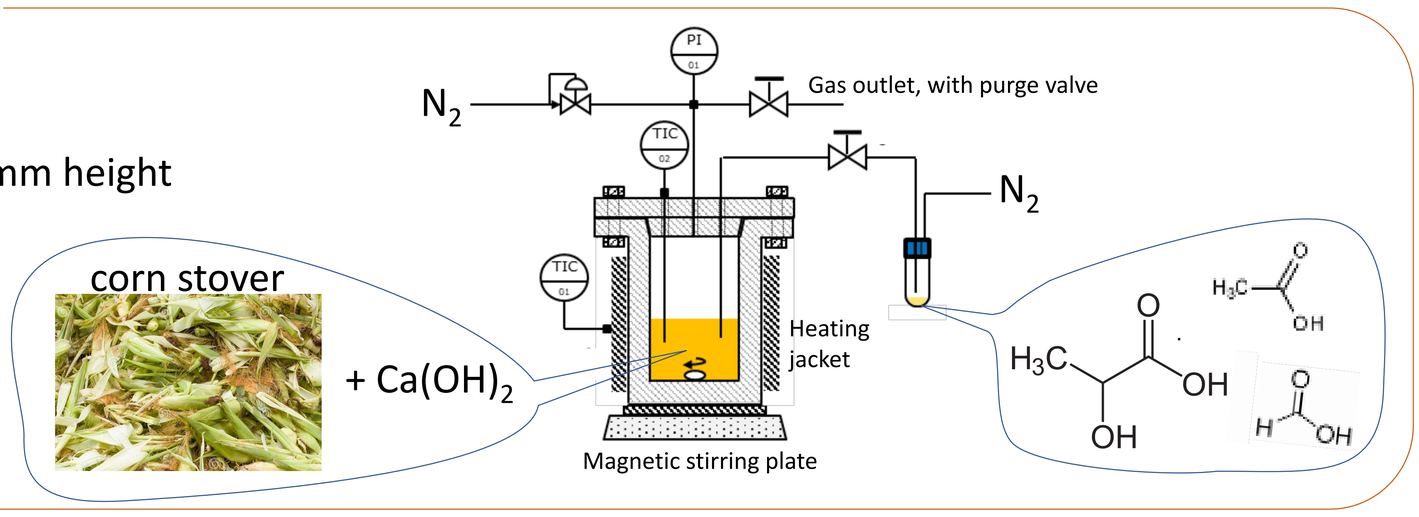
Heating jacket: Ceramic, 230 V, 4000 W, ø 95 mm, 160 mm height

Catalysts: $Ca(OH)_2$ 0,1 M

Biomass concentration: 5 wt %

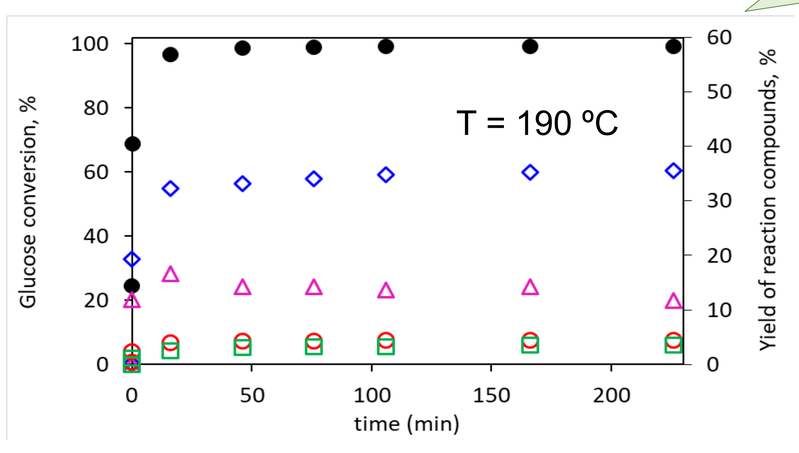
Initial glucose and xylose concentration: 50 mM

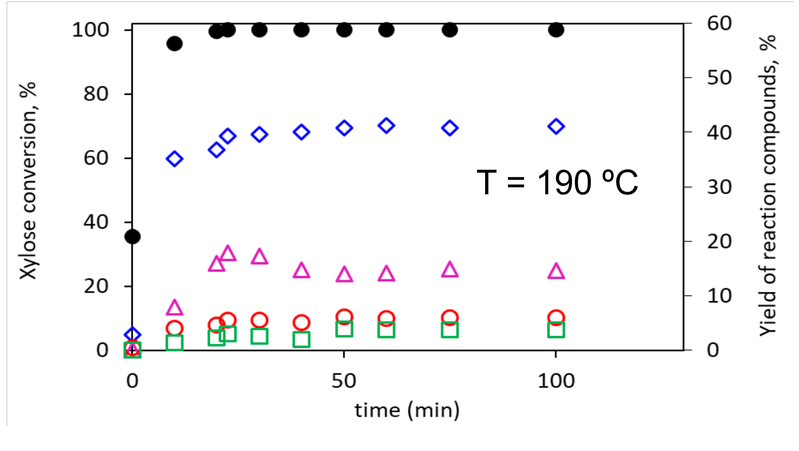
Reaction temperature: 190 °C and 225 °C



Results

Pure sugar monomer conversion and yield of reaction products





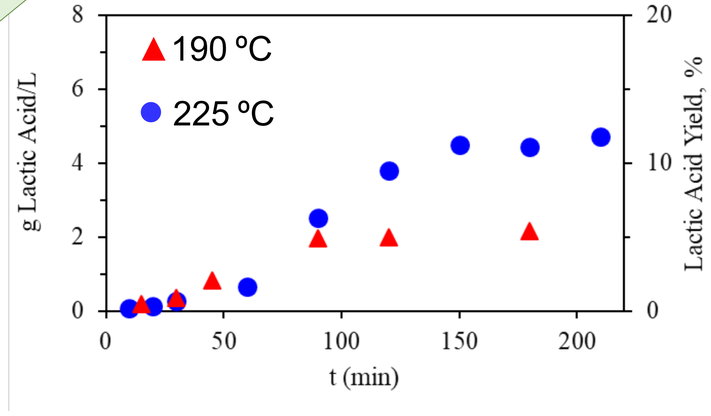
● glucose
◇ lactic acid
△ glyceraldehyde
□ acetic acid
○ formic acid
● xylose

The presence of retro-aldol condensation compounds, such as glyceraldehyde, leads to the formation of LA as the main reaction product, with slightly higher yields on a carbon basis for xylose, 41 %, than for glucose, 37 %. The concentration of LA in the medium was similar for both sugars (3.1-3.2 g/L). Other reaction by products determined in the reaction medium were acetic and formic acids.

A substantial decrease in LA yield was observed at 190 ºC for corn stover compared to the pure monomers with maximum yields of 5.4 % and LA concentration of 2.2 g/L.

At 225 ºC, the maximum yield was 13.5 %, corresponding to a LA concentration of 5.5 g/L.

Lactic acid yield and concentration produced from corn stover



Conclusion

Both monomeric sugars, glucose and xylose, degrade rapidly in an alkaline environment, especially when compared to the conversion rate achieved by SWT without the addition of any external catalyst. The presence of key intermediates such as glyceraldehyde in the reaction medium proves that bases, such as $Ca(OH)_2$, catalyze the retro-aldol condensation sugar degradation pathway leading to the formation of lactic acid from glucose or xylose.

Furfural and HMF were no detected in significant amount in the reaction medium since Brønsted acids are needed to catalyze the dehydration of glucose and xylose to produce HMF and furfural, respectively.

A more in-depth study needs to be conducted to achieve higher yields by improving the previously required hydrolysis step of the polysaccharide fraction of corn stover into its monomers.

Acknowledgements

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